Phys 131 2016

Lecture 40

Thurs: Make Up Labs

Fri: Final Review

Final COVERS ENTIRE SEMESTER

Section 001 Weds Dec 14 8am

002 Mon Dec 12 10am

Gravitational Potential Energy

Consider an object falling from a distance toward a planet. Newton's Law of Gravity

$$F = G \frac{M_{planet} M_{obj}}{r^2}$$

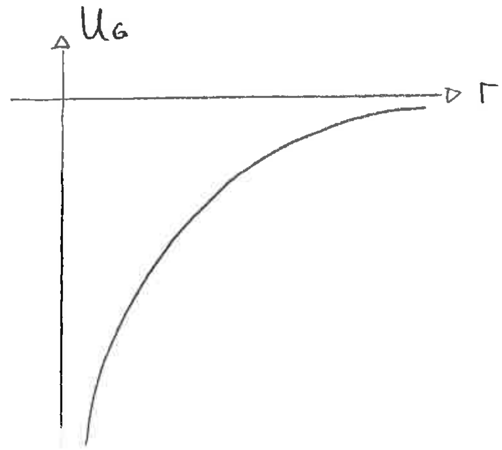
implies that the force increases as the object approaches the planet. Thus the acceleration of the object increases. We cannot use constant acceleration kinematics to address this situation. Would there be another way to determine, say, the speed of the object just before hitting the planet?

Fortunately we can show that the gravitational force is conservative and thus we can use work, potential energy and energy conservation to describe some aspects of this situation. It can be shown that the work done by gravity is $W = -\Delta U_G$ where the (general) gravitational potential energy is:

$$\boxed{U_G = -G \frac{m_1 m_2}{r}}$$

Quiz 1

We can plot this and it indicates that as r increases, U_G increases.



We can also show that near to the surface of a large object,

$$U_G \approx U_{surface} + mgy$$

where g is the acceleration due to gravity near the surface (see pg 346)

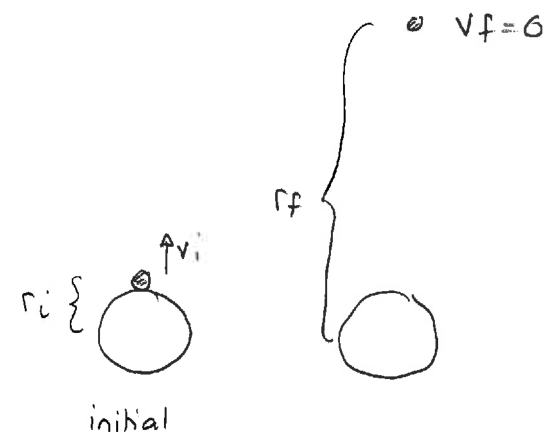
Example: The moon of Mars, Phobos, has mass 1.1×10^{16} kg and radius 11.3×10^3 m. A ball is thrown from its surface with speed 5.0 m/s

a) Determine the distance from the center of Phobos at which the ball stops

b) At what speed must the ball be thrown to escape Phobos.

Answer: Energy is conserved. So

$$E_f = E_i$$



$r_i = 11.3\times10^3$ m

$v_i = 5.0$ m/s

$r_f = ?$

$v_f = 0$ m/s

a)

$$\cancel{K_f} + U_{Gf} = K_i + U_{Gi}$$

$$-G\frac{\cancel{m} M_p}{r_f} = \frac{1}{2}\cancel{m}v_i^2 - G\frac{\cancel{m} M_p}{r_i}$$

$$\Rightarrow -G\frac{M_p}{r_f} = \frac{1}{2}v_i^2 - G\frac{M_p}{r_i}$$

$$\Rightarrow -6.6\times10^{-11}\frac{Nm^2}{kg^2}\frac{1.1\times10^{16}kg}{r_f} = \frac{1}{2}(5.0m/s)^2 - 6.67\times10^{-11}\frac{Nm^2}{kg}\frac{1.1\times10^{16}kg}{11.3\times10^3m}$$

$$= 12.5m^2/s^2 - 65m^2/s^2$$

$$-\frac{7.26\times10^5 m^3/s^2}{r_f} = -52m^2/s^2$$

$$\Rightarrow \quad r_f = \frac{-7.26\times10^5\,m^3/s^2}{-52\,m^2/s^2} \quad \Rightarrow \quad r_f = 1.4\times10^4\,m$$

b) Here $r_f \to \infty$ $\quad \Rightarrow \quad -G\frac{M_p}{r_f} \to 0$

$$\Rightarrow \quad 0 = \frac{1}{2}v_i^2 - G\frac{M_p}{r_i} \quad \Rightarrow \quad v_i^2 = \frac{2GM_p}{r_i}$$

$$\Rightarrow v_i = \sqrt{\frac{2GM_p}{r_i}} = \sqrt{\frac{2\times6.67\times10^{-11}\,Nm^2/kg^2\times1.1\times10^{16}\,kg}{11.3\times10^3\,m}}$$

$$\Rightarrow v_i = 11\,m/s \quad \boxtimes$$

Diagnostic Test